information on fixing, hardening, imbedding, sectioning and staining, also on selecting diatoms, in the chapters on "mounting" now at the end of the book. The number of pages has been increased from 132 to 186.

A NEW method of attacking the problem of determining the degree of ionisation of complex solutions is given by Prof. J. G. Macgregor in the *Transactions* of the Nova Scotian Institute of Science just issued. The number of free ions per unit volume can be studied in the case of the two simple salts separately by means of the conductivity. These numbers are functions of the dilution, and can be expressed graphically in the form of curves. From these two curves, by a neat graphical construction, Prof. Macgregor deduces the concentration of the ions in the solution resulting from the mixture of the two simple solutions, a complicated algebraical process being thus avoided. The method is applied, in a subsequent paper in the same volume by Mr. J. Barnes, to solutions containing a common positive ion, potassium chloride and sulphate. It was found to be possible in this way, given the dissociation theory and data obtainable from simple solutions, to predict the electrical conductivity, specific gravity and surface tension of fairly dilute solutions of potassium chloride and potassium sulphate within the limits of experimental error.

NOTHING can be more striking testimony to the advance of physical chemistry than the manner in which isolated phenomena, long known but previously unexplained, fall into line when attacked by modern methods. An excellent example of this is afforded by the paper of Messrs. Cohen and Van Eijk in the current number of the *Zeitschrift für physikalische Chemie* on physico-chemical studies of tin. As early as 1851 a curious molecular transformation of some tin organ pipes was noticed by Erdmann, and the same fact was rediscovered eighteen years later by Fritzsche at St. Petersburg, the tin crumbling to a grey powder. Since that time this phenomenon has been repeatedly studied by various observers, the causes being variously ascribed to low temperature, effect of shocks upon the crystalline structure, and velocity of cooling of the tin when originally cast. A preliminary dilatometric study of a grey tin showed the existence of a transition temperature at about 30° C., hence a transition element was constructed, having grey tin as one electrode and ordinary white tin as the other. A study of the electromotive force of this cell with varying temperatures showed that the reaction

$$\text{grey tin} \rightleftarrows \text{white tin}$$

was a reversible one with a transition point at 20° C. A careful determination of the same point by the dilatometric method gave the same value. All the observations of early workers are brought into line by this work. The authors point out that, except during a few warm days, all tin is in a metastabile equilibrium, and tends to transform itself slowly into the grey powder modification.

THE additions to the Zoological Society's Gardens during the past week include a Geoffroy's Cat (*Felis geoffroii*) from Paraguay, presented by Mr. W. A. Gillett; a Woodcock (*Scolopax rusticula*), British, presented by Mr. C. E. Lambert; a Common Snake (*Tropidonotus natrix*), British; a Tesselated Snake (*Tropidonotus tessellatus*), a Dark Green Snake (*Zamenis gemonensis*), European, presented by Miss Ash; a Black-headed Lemur (*Lemur brunneus*) from Madagascar, a Blue-tongued Lizard (*Tiliqua scincoides*) from Moluccas, a Bare-eyed Cockatoo (*Cacatua gymnopis*) from South Australia, two Undulated Grass Parrakeets (*Melopsittacus undulatus*, var.) from Australia, two Common Teguexins (*Tupinambis teguexin*) from South America, an Eyed Lizard (*Lacerta ocellata*), European, deposited; a Black-headed Bunting (*Emberiza melanocephala*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN FEBRUARY.

February 2. 6h. 56m. to 7h. 43m. Occultation of κ Piscium (mag. 5·0) by the moon.
2. 11h. 44m. Minimum of Algol (β Persei).
2. 18h. 5m. Transit (Ingress) of Jupiter's Sat. III.
5. 8h. 33m. Minimum of Algol (β Persei).
6. 8h. 36m. to 9h. 24m. Occultation of δ Arietis (mag. 4·5) by the moon.
7. 14h. 3m. to 14h. 49m. Occultation of 56 Tauri (mag. 5·4) by the moon.
8. 15h. 50m. to 16h. 29m. Occultation of η Tauri (mag. 5·2) by the moon.
14. Venus. Illuminated portion of disc = 0·801.
15. 13h. 20m. to 14h. 40m. Occultation of 55 Leonis (mag. 6·0) by the moon.
19. Saturn. Outer minor axis of outer ring = 16″·13.
22. 16h. Jupiter in conjunction with moon. ♃ 1° 31′ N.
25. 10h. 15m. Minimum of Algol (β Persei).
28. 7h. 4m. Minimum of Algol (β Persei).

UNITED STATES NAVAL OBSERVATORY.

CAPTAIN C. H. DAVIS, Superintendent of the United States Naval Observatory at Washington, has forwarded a copy of his report for the fiscal year ending June 30, 1899.

The great equatorial, 26 inches aperture, has been devoted to work beyond the reach of smaller instruments, and in particular to the spectroscopic determination of the motions of stars in the line of sight. Many measures were made of the diameters of Mercury and Venus, to determine the irradiation error, and it was established that this was a function of the magnifying power employed.

The spectroscopic observations were almost all made by the photographic method, the wave-lengths being obtained from measures taken with the large Harkness comparator made for eclipse reduction in 1869. The probable error in the velocity, as determined from a single plate, was about ± 0·71 mile per second. Good plates with well exposed comparison spectra have been obtained of α Tauri, α Aurigæ, α Canis Majoris, α Canis Minoris, α Cygni and ϵ Cygni, but many others have been failures, owing to the difficulties involved in the use of a lens only visually corrected. This has recently been remedied by the purchase of a correcting lens of 2·09 inches aperture, which alters the minimum focus from λ 5270 to λ 4341 without materially disturbing the total focal length from the object-glass. Extensive alterations have been made in the endeavour to remedy the air currents produced in the equatorial building on account of its connection with other rooms. The 12-inch equatorial has been employed in the systematic observation of minor planets, comets, occultations of stars and eclipses of Jupiter's satellites, the whole of which have been reduced and published. This telescope has also been used for the exhibition of celestial objects to the public on Thursday evenings. Including those admitted during day working hours, the number of visitors during the year has been 1623.

Transit observations have been continuously made throughout the year. The 9·14-inch instrument was dismounted on June 5, 1899, the whole observing staff being immediately transferred to the new 6-inch transit circle. The temporary fittings supplied at the installation of the 9·14-inch transit in 1893 are being replaced by permanent ones of new design. A meridian mark has been provided for the 6-inch instrument, and the performance of both this and the new steel altazimuth have given every satisfaction.

The new 5-inch altazimuth and the prime vertical instrument have been employed for determining variations of latitude and the constants of aberration and nutation.

The 40-foot photoheliograph was installed, for obtaining sun pictures, on October 11, 1898, and from this date to June 30, 1899, negatives were taken on 122 days. The sun's disc on these plates is 4·3 inches in diameter. The publications of the Observatory are well in hand. Volumes of observations for 1891 and 1892 are almost ready for distribution, and these will complete the record of work done at the old Naval Observatory. The American ephemeris for 1902 is issued, and it is hoped that the volume for 1903 will be issued in February 1900. In this, the adopted value of the apparent diameter of the sun will

be changed from $960''\cdot78$ to $961''\cdot50$, this alteration being based on the discussion of 35,842 meridian observations made at the principal observatories of the world.

A new departure in the administration of the Observatory was the appointment, in June 1899, of a Board of Visitors by the Secretary of the Navy, whose duty will be to examine and report upon the condition and requirements of the institution.

ON THE BLUE COLOUR IN WOAD.

THE old East Anglian proverb, "As blue as wad," occurs to one visiting the Woad Mill described by Mr. Darwin in NATURE, in 1896 (vol. lv. p. 36), as evidence that woad once yielded a blue dye. As a natural sequence one wonders what sort of blue it was and how it was obtained. A somewhat extended series of inquiries amongst those engaged in the woad industry, amongst those who have written on woad, and amongst botanical, archæological and chemical friends, failed for a long time to elicit the desired information. Curious as it may appear, an appeal to botanical and chemical works, to dictionaries and encyclopædias was equally unsuccessful. The last-named were pretty uniform in their statements about woad, in that it "was formerly used for dyeing blue, but is now superseded by indigo." Many of the books give an account of the woad-vat in which the manufactured woad is used with bran and lime as a ferment to change the insoluble indigo-blue into the soluble indigo-white; but they give no clue as to how woad may be used as a blue dye alone. It has been said that the blueness of woad was more or less a myth, and even if it ever possessed this quality it has long since been lost by continued cultivation.

As some of the facts elucidated in the attempt to find the blue colour may be of interest to others, they are herewith detailed:—

At the present time woad is grown and is manufactured in four places in the Fen country, viz. at Algarkirk, Wyberton, Skirkbeck, and Parson Drove; its use being as above stated, as a ferment in the indigo-vat to dissolve the indigo-blue. This process of dyeing by woad is difficult, cumbersome and expensive, but it yields the most permanent results. A genuine woad-dyed cloth resists sunshine, rain, and sea-air better than any other, but it is so expensive that only the very best articles are dyed in this way. The fastness of woad-dyed cloth is so proverbial that Prof. Hummel, of the Yorkshire College, Leeds, tells me the adjective "woaded" is now applied in the trade to any fast or permanent indigo dye: a woaded black meaning a black that has an indigo ground colour. The wool is dyed before it is woven, and the cloth may be distinguished by having pale blue or yellow threads in the selvedge.

But to return to the plant, many methods have been suggested by which the indigo in it may be extracted. In the earlier years of the present century, when we were at war with France, so great was the difficulty experienced by that nation in obtaining indigo that the Government offered a substantial prize for an efficient substitute. Attention was consequently re-directed to woad, and more than one method was suggested for the separation of indigo from it. However effective these may have proved in France and Italy, with me they failed, and failed so uniformly as to render the very numerous experiments extending over a period of five months unworthy of further notice. Suffice it to say that the experimental material was obtained from Parson Drove, Boston, Cambridge Botanic Gardens, and wild plants from Gloucestershire. Eventually the presence of indigo was demonstrated in these plants by the simple method of Dr. Hans Molisch,[1] who kindly further advised me, in a letter, to examine particularly the younger and expanding leaves. The method consists in keeping the fresh leaves for twenty-four hours in an atmosphere of ammonia, and then for a similar period in absolute alcohol. The ammonia precipitates the indigo in the leaves, while the alcohol dissolves out the chlorophyll: so that by cutting sections one can see the exact tissues in which the indigo occurs. These are those containing chlorophyll. The fibro-vascular tissue, the hairs, the epidermis, excepting the guard cells of the stomata, are free from it.

The quantity of indigo varies very much in different leaves; some turn a beautiful blue, while others come out of the absolute alcohol showing only a faint trace towards the base of the leaves. As a rule, the younger the leaf the more indigo it contains; some young leaves, however, hardly contain any. Old leaves have practically none in them, and become yellowish-green or greenish-white brittle objects after the above treatment.

1 "Ueber das Vorkommen von Indican im Chlorophyllkorn der Indicanplanzen." ("Berichten der Deutsch Botan. Gesell.," 1899. Bd. xvii. Hf. 6, p. 228, t. xviii.)

The process of separating the indigo is more delicate—perhaps it would be more correct to say it is a process simple enough in itself, but one in which certain precautions must be observed. Prof. Beijerinck, whose paper "On the formation of indigo from woad"[1] is summarised in NATURE, November 16, 1899 (p. 71), gives the following method: The woad leaves are put into a stoppered bottle, which is then filled with hot water, in such a way that all the air is expelled and the stopper put in so that no air bubble is allowed to remain between the top of the water and the lower part of the stopper. The water assumes a pale yellowish tint—the colour of sherry—with a green fluorescence. On the addition of a caustic alkali it darkens and becomes greenish. If a dilute acid be now added the indigo falls as a blue precipitate. The first time this method was tried with Parson Drove woad its success was complete; the long sought-for blue colour fell in abundance. Prof. Beijerinck tells me that in the month of September he obtained ·09 per cent. of pure indigo-blue from plants grown in Holland.

A considerable number of experiments have been made with the Parson Drove woad, the outcome of which may thus be summarised. The elaborate precautions for excluding the air are not absolutely necessary—simply pouring boiling or nearly boiling water on fresh woad leaves, so that they are completely covered, answers well enough. If to the infusion thus obtained caustic potash, caustic soda, strong ammonia or lime-water be added, the colour changes from yellowish to greenish. Any woollen fabric now dipped into this alkalised infusion will, on exposure to the air, pass from greenish to blue—not the dark blue one had expected, but a beautiful pale azure blue. This change takes place at once if the fabric be immersed in any of the dilute mineral acids. The blue colour thus obtained cannot be called fast, as it will not withstand the action of alkalis or even of soap. It is very subject to variation, being often greenish-blue, grey, or even dove colour. This depends on the age and quality of the woad leaves, as well as on the details of manipulation. In brief, the process consists in simply making an infusion and treating it first with a caustic alkali, then with an acid. The following points have, however, to be attended to: the leaves must be young, they must be fresh, the water must be boiling or nearly so, the infusion must not be left too long before the alkali is added, nor must the addition of the acid be too long delayed. The infusion must be cold before it is treated. If these precautions be not observed, instead of the indigo-blue, that peculiar brownish-black compound is formed which is the *bête noir* of the woad experimenter.

In order to determine the quantity of indigo in Parson Drove woad in plants of various ages: half a kilogramme of leaves, 28, 30, 34 and 66 days old, was found to yield respectively 1·5, 2·4, 2·1, and 0·6 grammes of impure indigo.

The indigo obtained from different experiments varied much in colour; one specimen was an exceedingly beautiful light blue; mostly, however, it was dark blue, which became when dry more or less green. When this, however, was powdered and dissolved by the aid of slaked lime and ferrous sulphate, it dyed cotton articles bright indigo-blue. With regard to the time the leaves should be allowed to infuse, a series of experiments in which 30 c.c. of an infusion were examined at the end of 30 minutes, $1\frac{1}{2}$, 2, 3, 6, 9, 12, 24 and 48 hours, showed that the first 30 c.c., *i.e.* at the end of 30 minutes infusion, contained as much indigo as any of the others; while after the 6th hour the indigo-blue was replaced by the black-brown precipitate. It is probable that the agitation of the vessel in pouring off the successive quantities was the cause of this, for I have obtained indigo-blue from infusions at the end of 10 or 12 hours when they have not been disturbed.

May I ask if any of your readers can help me by suggesting the process by which the mediæval dyers got a blue dye from the prepared woad? Indigo was not introduced into Europe as a commercial article till the middle of the sixteenth century, and even then its employment was for some considerable time more or less prohibited by legal enactments. That woad was used in this country long prior to this is shown by the indenture which still exists between the woad merchants of Amiens and

1 "Koninklijke Akademie van Wetenshappen te Amsterdam," October 25, 1899.